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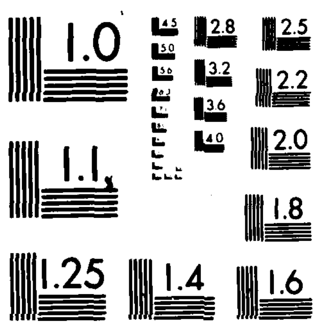

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HIGH LATITUDE ELECTRODYNAMICS

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Nov 1982

The last five years has been marked by rapid advancements in our understanding of electric fields in near-earth space. In no small part these advances have resulted from simultaneous measurements of electric fields, magnetic fields and charged particle fluxes by polar orbiting satellites above the high-latitude ionosphere. The measurement provide new evidence concerning the nature of large-scale magnetospheric convection and small scale processes leading to the field-aligned acceleration of auroral electrons. This paper reviews obervational evidence for the existence of parallel electric fields and several steady state, theoretical mechanisms by which these electric fields are sustained. Some implications of the existence of parallel electric fields for global magnetospheric modelling are also considered.

Parallel electric fields ($E_\parallel$) have occasionally been detected above the aurorae at altitudes greater than 1000 km. More often, their existence is inferred from other measurements. Intense, rapidly varying electric fields ($\overline{E}$) perpendicular to the magnetic field ($\overline{B}$), also known as electrostatic shocks, are frequently observed at high altitudes but not at ionospheric altitudes. Equipotential contours associated with these fields must cross magnetic field lines at some intermediate altitudes. At these altitudes equipotentials close across magnetic field lines and $\overline{E}$ has a significant component along $\overline{B}$. The existence of $E_\parallel$ is also inferred from measurements of downcoming, auroral electron and upmoving, accelerated ion beams.

Mechanisms invoked to explain steady-state parallel electric fields include the thermoelectric effect, anomalous resistivity, quasi-neutral potentials and double layers. The theory of the last two mechanisms as well as computer simulations by Chiu and Schulz (1978) and by Wagner et al., (1981) will be discused in detail.

Field-aligned potential drops affect the moments of magnetospheric particle distributions. By opening or closing the atmospheric loss cone, $E_\parallel$ modulates the intensity of Birkeland currents ($j_\parallel$). They also affect the distribution of particle pressures in the magnetosphere. To extend magnetospheric simulation models, such as that developed by the Rice University group, to include $E_\parallel$ requires a reexamination of the underlying physics. A variational principle will be presented from which an appropriate form of Poisson's equation is derived and from which parallel electric fields arise in a natural way. The varied quantity is equivalent to the total particle and electrostatic field energy. By minimizing this quantity the particle pressure distributions that drive $j_\parallel$, electrically coupling the ionosphere and magnetosphere, are calculated.

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